Impurity mode induced turbulent particle transport and its temperature screening effect

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Turbulent transport of impurity ions with hollow density profiles (HDPs)[1-4], which are widely observed in magnetically confined fusion plasmas and desirable for reactors, is self-consistently investigated. A full gyrokinetic description is employed for main and impurity ions. Instead of conventional ion temperature gradient (ITG, including impurity ITG) and trapped electron modes (TEMs), impurity modes (IMs), driven by impurity ion density gradient opposite to that of electrons, are considered. The impurity ion flux induced by IMs is shown to be approximately one order of magnitude higher than that induced by TEMs when both kinds of modes coexist. Main ITG and electron temperature gradient (ETG) are found to reduce influx of impurity ions significantly, resembling temperature screening effect of neoclassical transport of impurity ions. The simulation results such as peaking factor of the HDPs of impurity ions and the effects of main ITG are found in coincidence with the evidence observed in argon injection experiment on HL-2A tokamak. In addition, enhancing of peaking factor of the HDPs of impurity ions in plasmas of low electron density gradient was observed in experiment and simulation as well. Thus, the IM turbulence is demonstrated to be a plausible mechanism for the transport of impurity ions with HDPs. A strong main ITG[5], ETG, and a low electron density gradient, as observed in the edge of I-mode discharges, are expected to be beneficial for sustainment of HDPs of impurity ions and reduction of impurity accumulation in core plasma[6].

References

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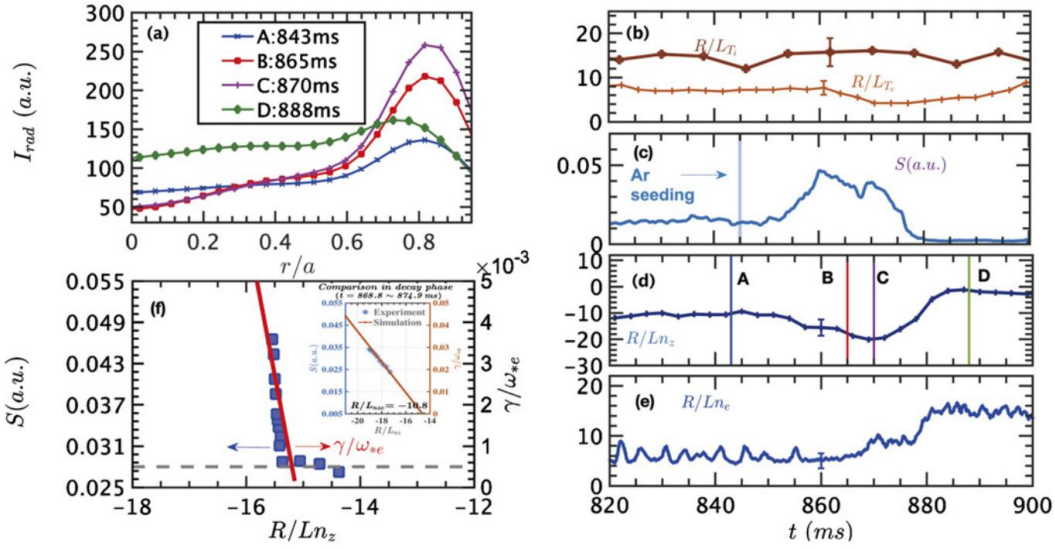

Figure1 Radial profile of radiation intensity (a) at t = 843, 865, 870, 875, 888ms. Temporal evolutions (b) normalized ion and ETGs, (c) integrated IM turbulence intensity; normalized gradients of (d) impurity argon density R/Lnz, (e) electrons density R/Lne and (f) the integrated turbulence intensity (grey dash denotes the background fluctuation level) and the growth rate of IM versus R/Lnz at normalized radius ρ = 0.75[5].